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A comparative study of detectors and media for relative dose measurements in kilovoltage small beams

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Purpose/Objective: The XRAD225Cx is a small animal radiotherapy device using a medium energy beam (225 kVp) and small circular fields. In addition to the half-value layers and the absolute dose rate, the commissioning of this equipment requires relative dose measurements such as percentage depth dose (PDD), Output Factor (OF) and Tissue Maximum Ratio (TMR). The aim of this study was to compare two media and four detectors to determine the optimal conditions to perform these relative measurements.
Materials and Methods: RW3 material is known not to be water-equivalent at medium energy for absolute dose measurements. To evaluate the impact of this medium for relative dose measurements, PDDs were obtained in water and RW3 for a 10x10 cm^2 field with a plane-parallel ionization chamber and EBT2 Gafchromic films. Simulated PDDs were generated using a GATE Monte Carlo model of the irradiator. To study the influence of the detector, four dosimeters (an IBA SFD diode, a PTW PinPoint 31014 microchamber, EBT2 films and a PTW-23342 plane-parallel chamber) were compared for OFs, PDDs and TMRs in water and/or RW3 depending on the dosimeter sealing. Measurements were performed in small fields (20, 15, 10, 8, 5 and 2.5 mm in diameter). OFs, PDDs, and TMRs were also computed with the Monte Carlo model.
Results: Measured and simulated PDDs were similar in water and RW3. Regardless of media and detectors, simulated and measured OFs showed no differences down to a diameter beam of 5 mm. For the smallest beam (2.5 mm),ionization chambers yielded large discrepancies (up to -22%) compared to SFD and EBT2 measurements and Monte Carlo simulations. This is due to the size of the sensitive volume of chambers compared to beam diameter. For PDDs and TMRs, measurement accuracy depends on spatial resolution in depth of the detector. Therefore, PinPoint chamber was not used. Plane ionization chamber and film measurements were closed to Monte Carlo computed results. SFD diode results showed significant discrepancies (up to 9%) due to the important variation in the relative energy response of the diode at 225 kVp.
Conclusions: For relative measurements, RW3 can be used instead of water at 225 kVp for convenient considerations. For OFs, all studied detectors may be used down to a beam diameter of 5 mm. For smaller beams, measurements should be performed with the SFD diode or Gafchromic films. For PDDs and TMRs, plane ionization chamber can be used down to a beam diameter of 5 mm. Gafchromic films are suitable whatever the beam diameter.

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Sensitivity of three commercial dosimeters to delivery errors in helical tomotherapy

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Purpose/Objective: To assess the sensitivity of three different commercially available dosimetry systems in detecting treatment delivery errors during helical tomotherapy pre-treatment verification.
Materials and Methods: Three dosimeters 1) MatriXX Evolution (IBA®) with OmniPro-ImRT software 2) ArcCheck®(Sun Nuclear®) with SNC Patient software 3) EDR-2 film with cheese phantom and RIT software were considered. A head and neck helical tomotherapy plan was edited to introduce known systematic errors in couch speed, gantry speed, gantry start angle, and projection time. The magnitude of each introduced error was +2% and +4% relative to the original treatment plan. All measurements were performed at the same time to minimize day-to-day and phantom setup variations. For each dosimeter the measured dose for the original plan was compared to each altered plan with a Gamma analysis using 3%/3 mm pass criteria.
Results: The gamma pass rates are shown in Table 1. In each case an introduced error resulted in a decreased gamma pass rate. Results were comparable across the three detectors. Sensitivity to couch speed, gantry speed, and start gantry angle were similar for each detector. All detectors were most sensitive to projection time errors.

Table 1: Gamma pass rates for each dosimeter and plan. Pass criteria used was 3% / 3 mm, 10% threshold

Plan/Error plan	% Gamma passing		
	MatriXX Evolution	ArcCheck	EDR-2 film
Original	97.6%	97.7%	97.2%
Couch speed 2%	92.34%	91.2%	88.45%
Couch speed 4%	73.97%	68%	67.21%
Gantry speed 4%	91.7%	93.7%	90.8%
Start Gantry angle 2%	93.07%	91.5%	Not measured
Start Gantry angle 4%	82.81%	63.46%	Not measured
Projection time 2%	73.07%	66.2%	71.11%
Projection time 4%	54.89%	42.1%	41.3%

Conclusions: All three dosimetry systems were sensitive to each introduced error. Additional work is underway to assess the impact of these errors on treatment plans and to include systematic/random error in MLC and jaw position. This work will also help to establish meaningful tolerance levels for quality assurance.

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Dosimetric verification of dose calculation algorithm during Total Marrow Irradiation with helical tomotherapy

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Purpose/Objective: To evaluate the accuracy of the dose calculation algorithm for the target (bones) and some sensitive structures (lungs, eyes, heart, kidneys) in total marrow irradiation (TMI) performed with helical tomotherapy (HT).
Materials and Methods: Thermoluminescent detectors (TLDs) were used to measure delivered doses. Dose optimization was performed with the HT treatment planning system. Doses were calculated for selected points in the target - bones (9 TLDs), in the central lung (11 TLDs) and in eye, heart, kidney (4 TLDs) in an anthropomorphic phantom. The target dose was 12 Gy to the skeletal bone. A dose of 2 Gy was delivered 6 times. We compared the calculated dose to the measured dose.
Results: For each dosimetric point, the measured value was averaged and corrected by the MVCT scan value and converted according to the calibration factors. The mean difference between the measured and calculated dose for the bone TLDs was 1.2% (with a range of -4.2% to +5.0% for individual detectors included in this group), indicating that the measured dose was higher than the calculated dose. For the lung-TLD group of detectors, the corresponding difference was -1.9% (range, -9.0% to +7.6%). At 11 points, the measured dose was lower than the calculated dose, with the largest differences observed in the region located in the kidney (-9.2%) and lungs (-9.0%).